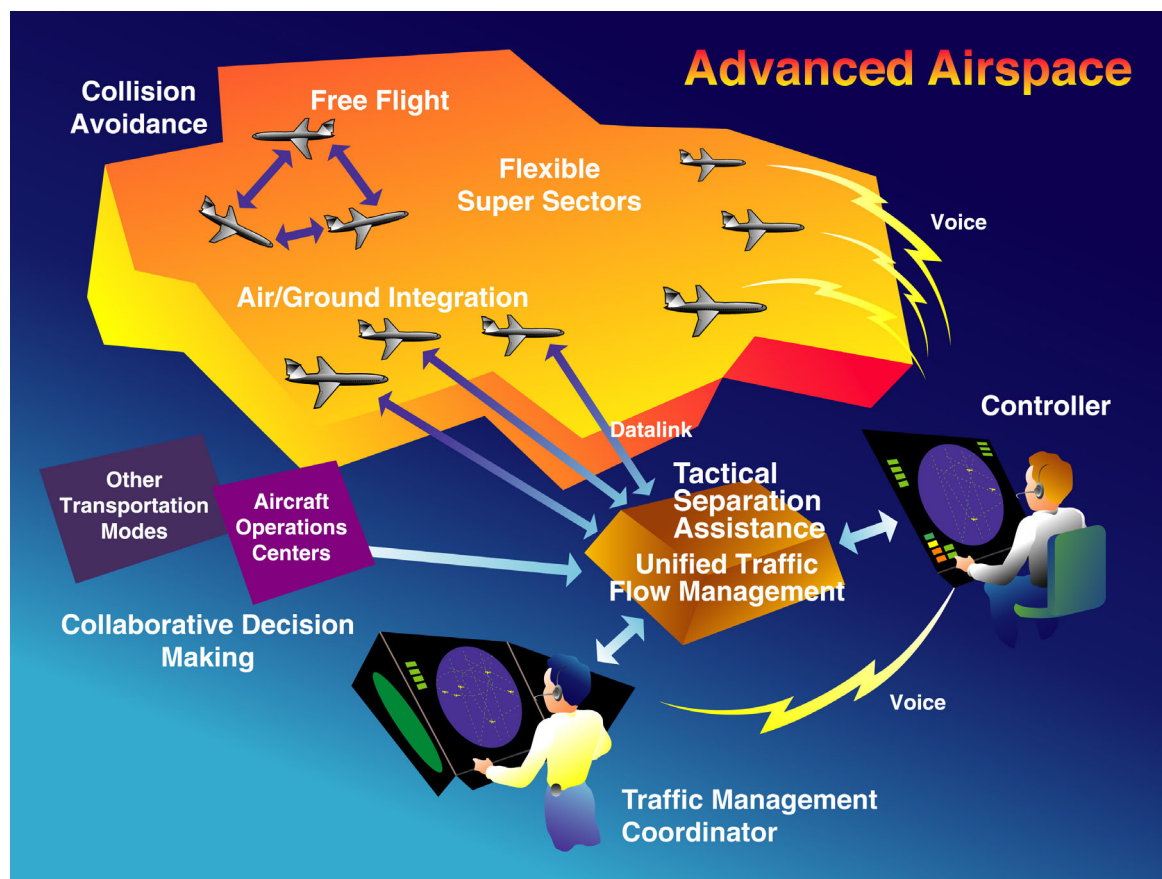


Advanced Airspace Concept



VAMS TIM #3; January 14-16, 2003
Presenters: Heinz Erzberger and Russ Paielli
NASA Ames Research Center
Moffett Field, CA

Performance Goals

(Current separation standards)

- Application to selected airspace from takeoff to touchdown
- Double capacity of en route airspace
- Double capacity of terminal area airspace
- Increase landing rate of runways by 20%
- Reduce operational errors by 50%
- Significant reduction in controller workload

Overview of Advanced Airspace Concept

- . Ground-based system generates conflict-free 4D trajectories and sends them to equipped aircraft via data link

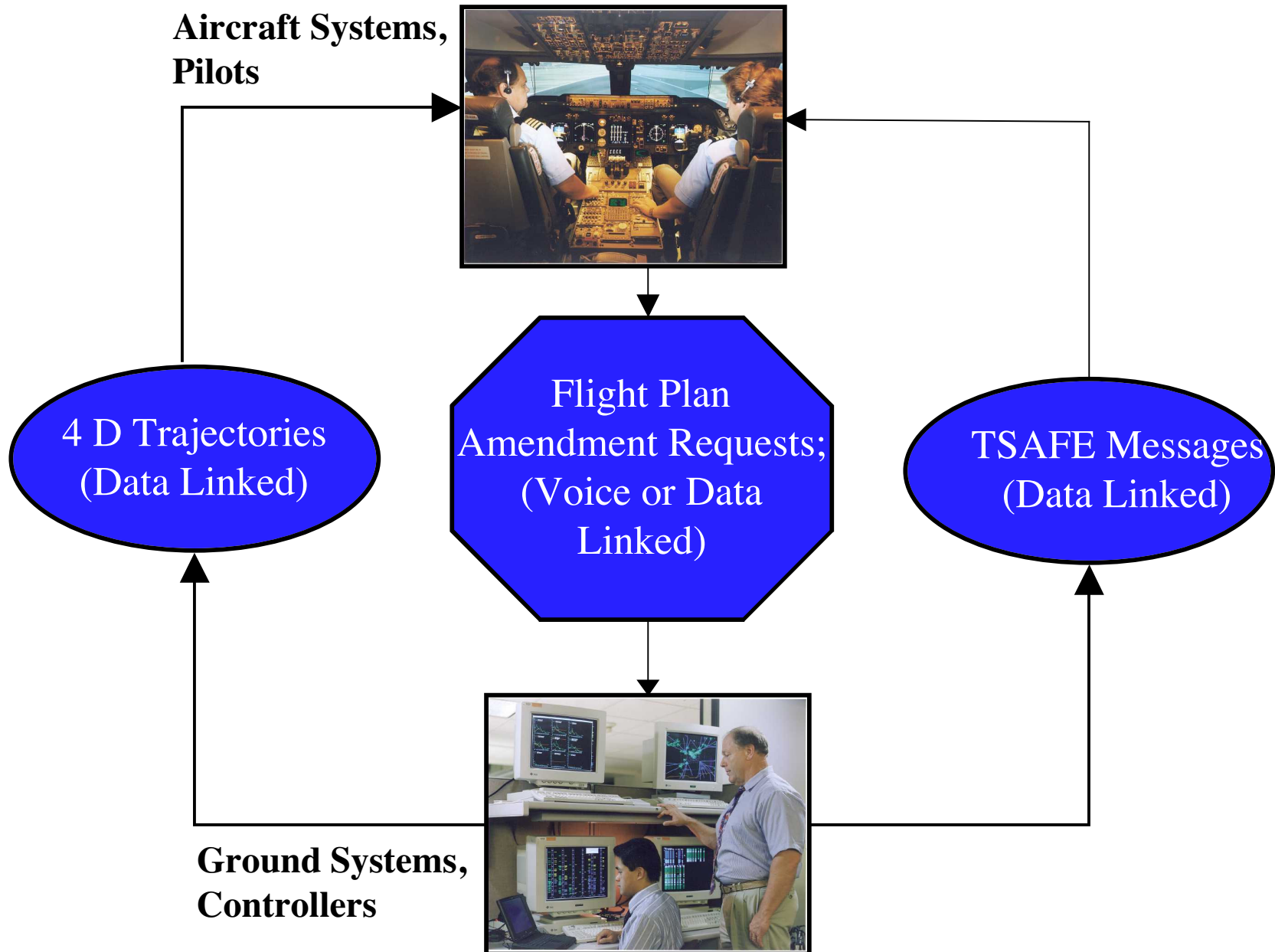
- . Pilots use Flight Management Systems to execute trajectories

- . Independent ground-based system checks for near term conflicts and issues advisories to maintains safe separation

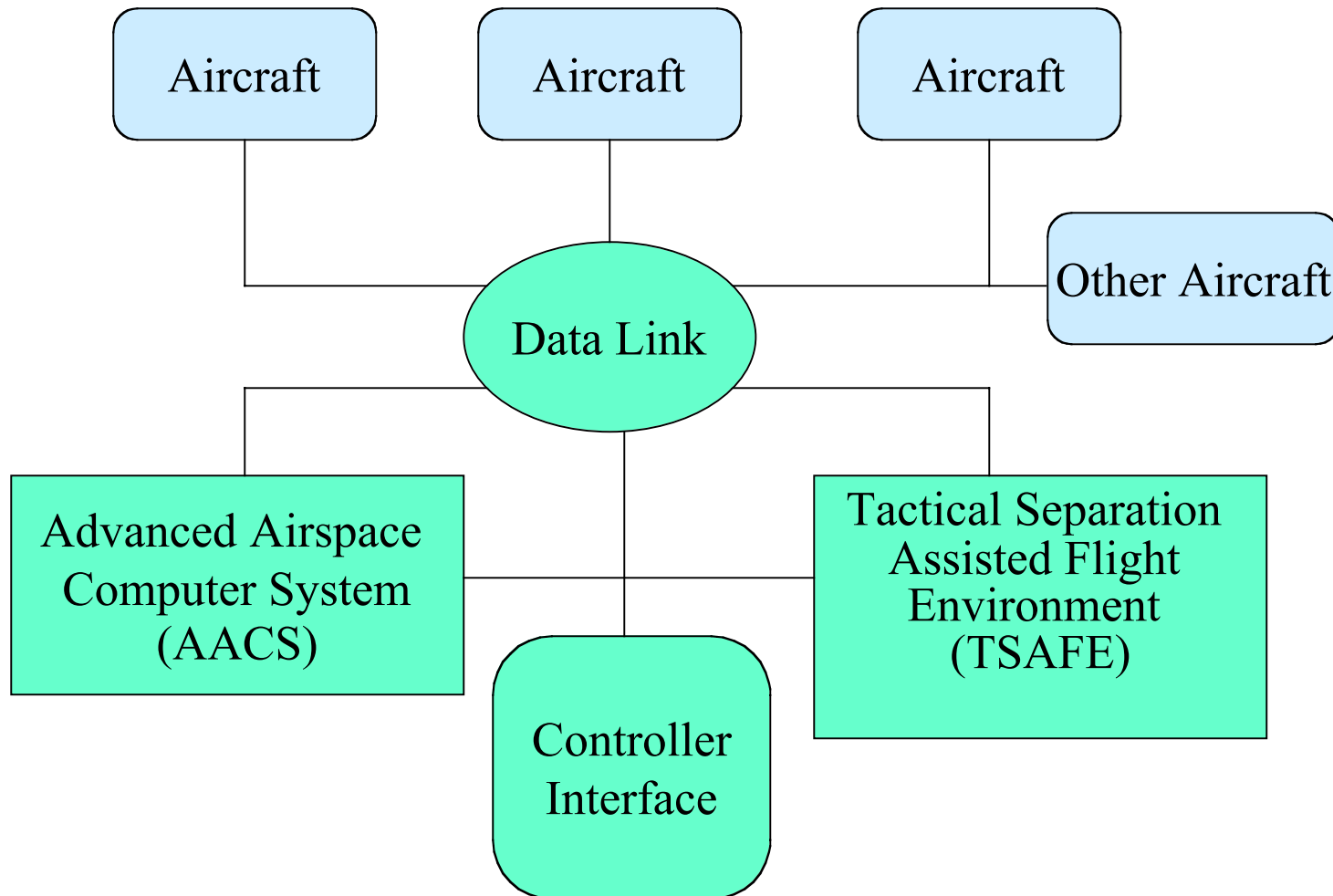
- . Advanced Airspace sectors consist of several conventional sectors combined into super-sectors

- . Controllers handle strategic tasks and unequipped aircraft but are not responsible for separation assurance of equipped aircraft in Advanced Airspace sectors

Ground-Air Interactions in Advanced Airspace

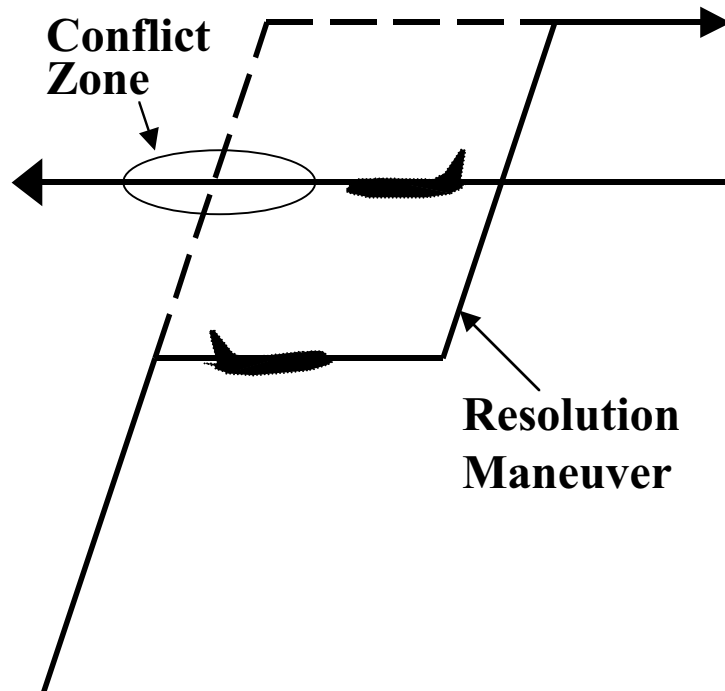


Advanced Airspace Architecture

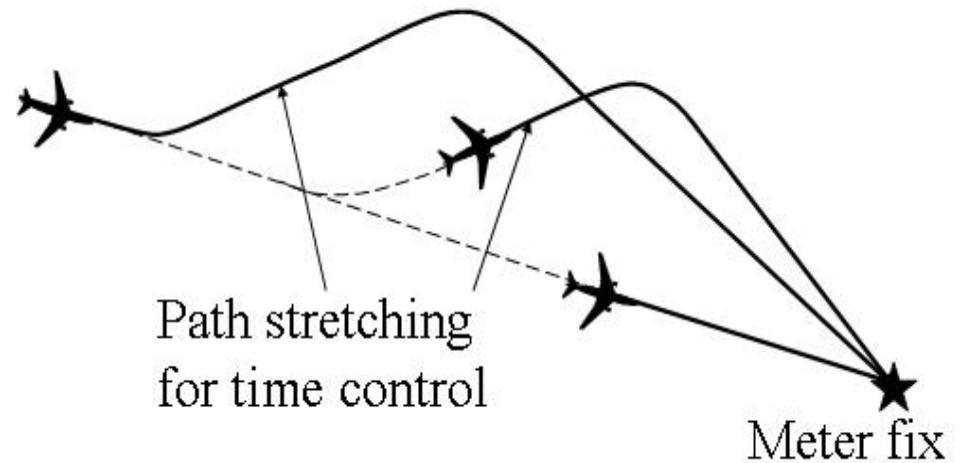


AACS Functions: En Route

Conflict Resolution,
Vertical Plane Maneuver

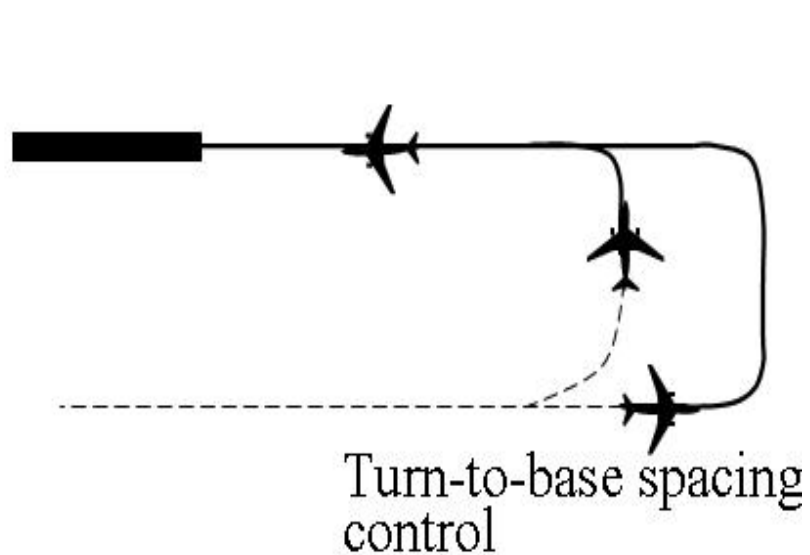


Arrival Metering

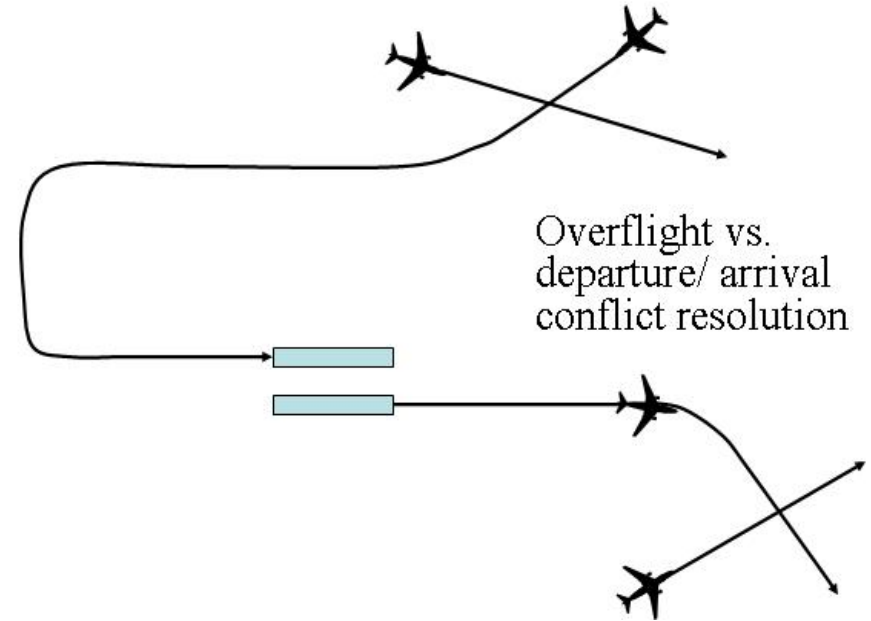


AACS Functions: Terminal Area

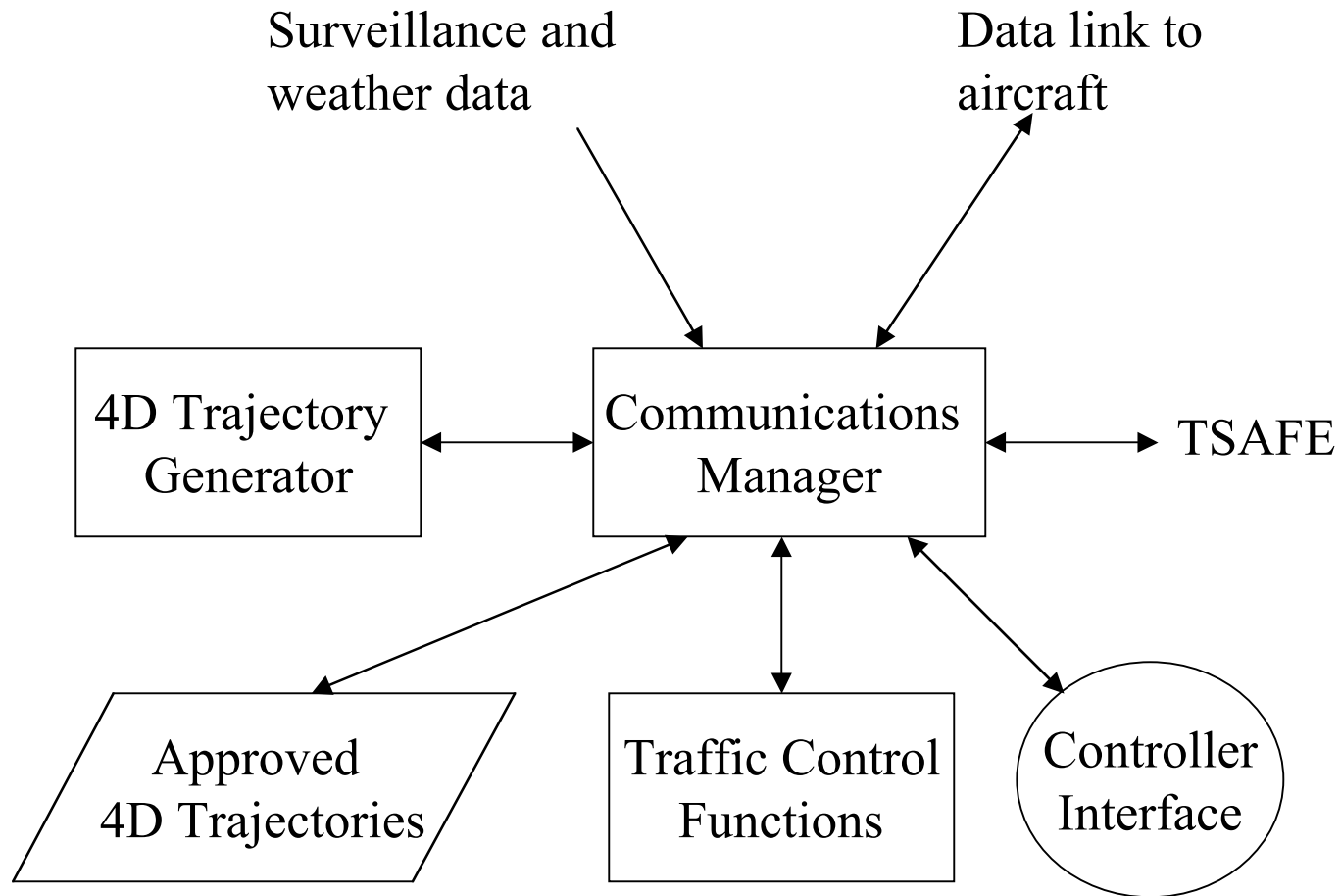
Final Approach Spacing



Departures/ Arrivals vs. Overflights



AACS Architecture



KEY IDEAS OF AUTOMATED AIRSPACE

- 4D trajectory assignment for equipped aircraft
 - Replaces (CTAS) trajectory prediction based on 2D flightplan, tracking data, winds
 - Aircraft requests trajectory, ground assigns trajectory
 - Specified tolerances on flight technical error
- Automated conflict detection and resolution on ground, amended trajectories uplinked to resolve conflicts
 - Increases sector capacity
 - Reduces operational errors
- Automatic detection of trajectory non-conformance and handoff to human controller when necessary

TRAJECTORY SPECIFICATION

- Equipped aircraft will be assigned 4D trajectories with flight technical error tolerances
 - Parametric models needed for all trajectory segment types: cruise, climb, descent, turn, etc.
 - Error tolerances specified for along-track, cross-track, and vertical axes
 - Error tolerances based on RNP, but could be relaxed in sparse traffic
 - Along-track assigned position updated periodically to reduce need for throttle control
- National/International standard needed for FMS compatibility with ground systems

TSAFE FUNCTIONS

- Conforming equipped aircraft:
 - Confirm that trajectory assignments from AACS are conflict free for next ~4 minutes
 - Monitor aircraft conformance to assigned trajectories
 - Detect and alert aircraft for critical maneuvers and no-transgression zones
- Non-conforming and unequipped aircraft:
 - Detect imminent potential conflicts
 - Generate resolution maneuvers when necessary
 - Handoff to human controller if necessary

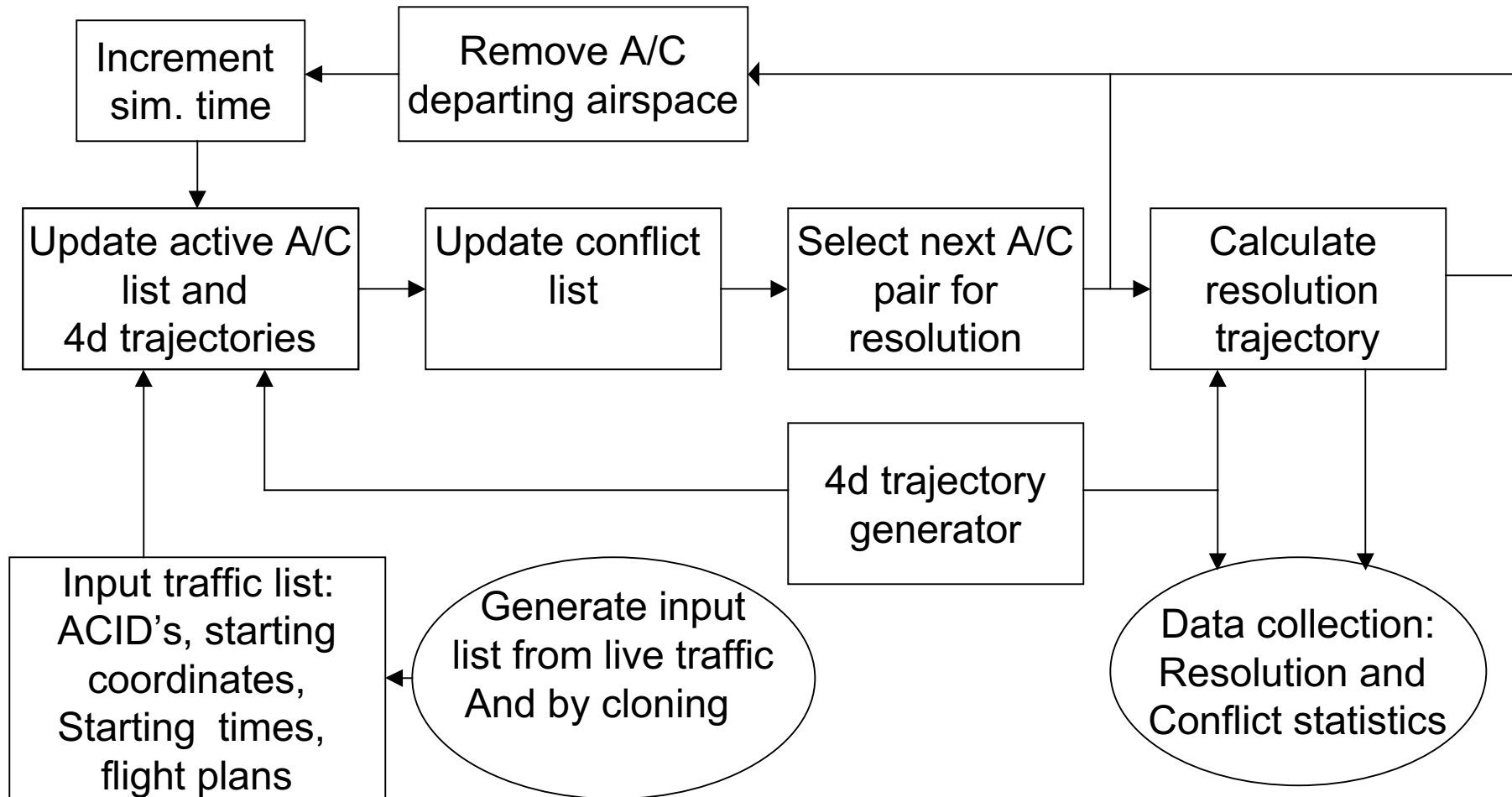
Evaluation Strategy

- Airspace Capacity
 - Initial focus on en route transition airspace
 - Performance of resolution algorithms
 - Use fast time simulation based on ACES/FACET
- Safety
 - Effectiveness of TSAFE to detect near term conflicts and to prevent operational errors
 - Use of live traffic in shadow mode to evaluate accuracy in predicting loss of separation incidents
 - Analysis of failure modes
- Controller workload
 - Estimate workload using human performance models in fast time simulation environment

Procedure for using Fast Time Simulation to Evaluate Capacity

- Record live traffic entering selected airspace
 - Record entry point coordinates, entry times, and associated flight plans for each aircraft
 - Subset of Cleveland Center airspace
- Generated 4D trajectories for each aircraft starting at entry points and times
- Generate and update conflict list as aircraft enter and depart airspace
- Determine trajectories that resolve conflicts using procedure-based algorithm
- Increase traffic density in steps by cloning live traffic until capacity limit is reached
 - Capacity limit is reached when resolution rate exceeds a limit value

Fast Time Simulation of AAC



Safety: Evaluation of TSAFE

- Short range conflict detection algorithms inserted into CTAS
- Evaluation of detection efficiency using live data and archived records of operational errors in progress
- Operational error cases under evaluation:
 - Erroneous climb or descent clearance: 9 cases
 - Misunderstood altitude at meter fix: 2 cases
 - Level off at wrong altitude: 1 case
 - Overtake during arrival merge: 1 case
 - Erroneous direct clearance: 1 case
 - Attempt to resolve non-existent conflict: 1 case

Controller Workload and Performance Analysis

- Purpose
 - . Model & Analyze the AAC Concept of Operations using Human-system Performance Model (Air MIDAS)
 - . Estimate workload as function of traffic density and controller tasks
- Status
 - . Airspace Design completed (Cleveland combined sectors 47& 49)
 - . Procedures for AAC, TSAFE & Baseline operations defined and encoded
 - . Baseline Operations Simulation Run

Concluding Remarks

- Advanced Airspace Concept has potential to increase capacity substantially by reducing controller workload associated with tactical separation monitoring and control
 - Application to en route, terminal airspace and final approach control
- Elements of Concept have been outlined:
 - Ground-based system provides 4D conflict free trajectories to equipped aircraft via data link
 - TSAFE provides separation assurance advisories to pilots via data link and protects against certain types of failures
 - Controller performs strategic control tasks and handles unequipped aircraft
- TSAFE has potential to reduce operational errors in current system
- Evaluation of concept will focus initially on determining capacity of en route transition airspace using fast time simulation